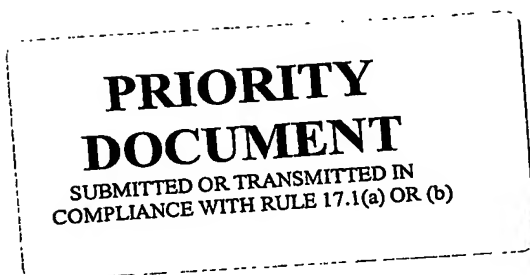




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I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PS 2908 for a patent by MARINE-WATCH LTD as filed on 12 June 2002.

WITNESS my hand this  
Nineteenth day of June 2003

**JONNE YABSLEY  
TEAM LEADER EXAMINATION  
SUPPORT AND SALES**



**ORIGINAL**

**AUSTRALIA**

**Patents Act 1990**

**PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:**

**Helix Antenna**

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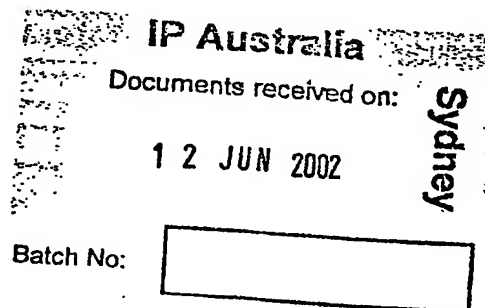
**Name and Address of Applicant:**

Marine-Watch Ltd, an Australian Company ACN 094 336 268, of Suite 3, 9  
Narrabang Way, Belrose, New South Wales, 2085, Australia

**Names of Inventors:**

John Craggs and Christopher Boyce Meulman

**This invention is best described in the following statement:**



## **HELIX ANTENNA**

### **Field of the Invention**

The present invention relates generally to antennas and, in particular, to helical antennas.

### **Background**

In Mobile Satellite System (MSS) networks, antenna performance at the mobile terminal is critical in determining the performance of the overall system. Considerable development work has thus been performed globally relating to performance and implementation of antenna designs that are suitable for terminals in such networks.

Patch antennas were initially considered because of their low physical profiles, and their theoretical peak gains of greater than 7dB. In practical implementations, however, much lower peak gains were achieved. Furthermore, these antennas have narrow frequency bandwidth performance, and poor axial ratio performance at off-boresite angles, thus typically limiting their coverage to 25 degree elevation angles.

The aforementioned low antenna gain has been addressed by using phased array techniques which involve driving multiple antenna elements in parallel using a phased drive network. This enables higher overall antenna gain to be achieved while accepting lower gains from the individual antenna elements. High gain phased-array antenna arrangements using patches, with either manual or automatic antenna pointing, can typically provide between 9dB and 18dB of antenna gain. The phased array drive networks introduce undesirable losses into the antenna arrangements, however, and are complex to design across a broad range of operating frequency.

Low gain passive antennas using multifilar helices or patch elements have been used in MSS networks, typically exhibiting antenna gains up to 6dB.

### **Summary**

The antenna concept disclosed herein provides a simple medium gain antenna, based on a low profile helix terminated with a spiral. The antenna offers significantly higher antenna gain than patch antenna arrangements.

According to a first aspect of the invention, there is provided an antenna comprising  
5 a ground plane, a helix disposed above the ground plane, the helix being connectable to a communications apparatus at a helix end located near the ground plane, and a spiral substantially centred on the axis of the helix the spiral having an outer end thereof connected to the other helix end, said spiral thereby terminating the antenna.

According to another aspect of the invention, there is provided an antenna  
10 comprising a ground plane, a plurality of helix elements disposed above the ground plane, each said helix being connectable, via a respective feed line of an associated phased array feed network to a communications apparatus, at a helix end located near the ground plane; and a like plurality of spirals, each substantially centred on the axis of the corresponding one of the plurality of helix elements, said each spiral having an outer end thereof  
15 connected to the other helix end of the corresponding one of the plurality of helix elements, said spiral thereby terminating the corresponding helix element.

According to another aspect of the invention, there is provided an antenna comprising a ground plane, a plurality of helix elements disposed above the ground plane, each said helix being connectable, via a respective feed line of an associated switched  
20 element feed network to a communications apparatus, at a helix end located near the ground plane; and a like plurality of spirals, each substantially centred on the axis of the corresponding one of the plurality of helix elements, said each spiral having an outer end thereof connected to the other helix end of the corresponding one of the plurality of helix elements, said spiral thereby terminating the corresponding helix element.

25 According to another aspect of the invention, there is provided a method of impedance matching an antenna wherein the antenna comprises a ground plane, a helix

disposed above the ground plane, the helix being connectable to a communications apparatus at a helix end located near the ground plane, and a spiral substantially centred on the axis of the helix the spiral having an outer end thereof connected to the other helix end, said spiral thereby terminating the antenna, said method comprising the steps of  
5 adjusting a distance, from the ground plane, of the helix end located near the ground plane to thereby adjust the impedance of a tapered transmission line formed between the ground plane and a first quarter turn of the helix.

Other aspects of the invention are also disclosed.

### **Brief Description of the Drawings**

10 One or more embodiments of the present invention will now be described with reference to the drawings, in which:

Fig. 1 shows the disclosed helix antenna;

Fig. 2 shows side and plan views of the antenna;

Fig. 3 shows a typical azimuth radiation pattern for the antenna;

15 Fig. 4A shows a switched antenna arrangement using the antenna;

Fig 4B shows switch azimuth antenna gain patterns for the arrangement shown in Fig. 4A; and

Fig. 5 shows an elevation pattern for the antenna.

### **Detailed Description including Best Mode**

20 Where reference is made in any one or more of the accompanying drawings to steps and/or features, which have the same reference numerals, those steps and/or features have for the purposes of this description the same function(s) or operation(s), unless the contrary intention appears.

Fig. 1 shows the disclosed helix antenna. The antenna comprises a conductive  
25 ground plane 106 above which is disposed a helical coil 104 (alternately referred to in this description as a "helix", a "helical coil" or the like) that is electrically terminated at the

upper end of the helix 104 with a spiral 102. The helix antenna is depicted as having a vertical axis 100.

In a preferred embodiment, the helical coil 104 comprises between 1.5 and 3.5 turns. Furthermore, the helix 104 is approximately one wavelength plus minus 10% of a wavelength in circumference. In addition, the spiral 102 comprises between 2 and 4 turns, in a flat configuration normal to the axis 100.

Although the ground plane 106 is depicted as having a circular shape in Fig. 1, in fact the extent of the ground plane 106 is not critical, provided that it has an area greater than two thirds of a wavelength in diameter.

Fig. 2 shows a side view 224 of the helix 104 and the spiral 102, and also a plan view 232 thereof. Turning to the side view 224 the helix 104 has a first end 214 that is disposed a distance 216 above the ground plane 106. This first end 214 of the helix 104 has a radial position about the axis 100 as depicted by a reference numeral 214' in the plan view 232.

The helix 104, when wound in a clock-wise direction produces right hand circular polarization, and when wound in a counter-clockwise direction, produces left hand circular polarization. The number of turns of the helix can vary between 1.5 and 3.5.

The helix 104 in Fig. 2 depicts one example of a helix being wound in a counter-clockwise direction commencing from the first end 214 and comprises three and a quarter turns. The three and a quarter turns comprise a first turn 212-210, a second turn 208-206, a third turn 204-202, and a final quarter turn 200. The final quarter turn 200 of the helix 104 runs from a radial position depicted by the arrow 214' to a radial position depicted by the arrow 238 which is the upper end of the helix 104. The upper end of the helix is connected to the outer end of the spiral 102 at a radial position 238.

The first quarter turn of the helix 104, which extends from the first end 214 to a point 246, describes an angle 244 with respect to a dashed line 222. The remainder of the

helix 104 is uniformly wound with a pitch angle 220, which can vary between 3 and 7 degrees, referred to the horizontal reference line 222. The angle 244 can be adjusted to achieve a desired impedance at the input of the helix 104. Although the angle is depicted as being greater than the pitch angle 220, this is illustrative only, and other angles can be adopted according to the desired impedance. Furthermore, although an abrupt change between the angles 244 and 220 occurs at the point 246 in Fig. 2, in practice a smooth angular transition can be used.

The angle 244, together with the distance 216 of the helix first end 214 from the ground plane 106 establishes a distance 228 which is located a quarter turn from the helix first end 214. The radial location of the distance 228 is depicted by the reference numeral 238 in the plane view 232. The one quarter turn segment of the helix 104 between 214 and 238 forms a tapered transmission line with the ground plane 106. As noted, the distance 216 can be advantageously adjusted, for example by adjusting the angle 244, in order to match an input impedance of the helix 104 as desired.

The helix 104 has a second end 242 that is situated, in the present arrangement, three and a quarter turns from the first end 214 of the helix 104. The spiral 102 is connected by an outer end thereof to the second end 242 of the helix 104 at a radial location depicted by the reference numeral 238. The spiral 102 has a uniform inter-turn pitch distance 236, and spirals inwards from the aforementioned outer end that is connected to the second end 242 of the helix, to an inner end 234 of the spiral 102. Other types of spiral can also be used.

In a preferred arrangement the spiral 102 is located in a plane horizontal to the axis 100. The spiral 102 can however, in other arrangements, be formed to have a conical shape pointing either upwards or downwards.

Instead of a tapered transmission line being formed using the one quarter turn segment of the helix 104 between 214 and 238 and the ground plane 106, other

impedance matching techniques such as quarter wave transmission line matching sections can be used to connect the first end 214 of the helix 104 to the intended communication apparatus thereby achieving the desired impedance matching.

5 The helix can be made of wire, wound on a low loss, low dielectric constant former to support the helix and spiral. Alternately, the helix can be etched in copper on a thin low loss dielectric film which is then rolled to form a cylinder. Either method provides the necessary mechanical support for reliable operation and causes minimal disturbance to the radiated wave.

10 This antenna element can be advantageously used in the frequency band between 1 GHz and 8 GHz, however it can also be used outside this frequency band. Furthermore, the addition of the spiral 102 to terminate the helix 104 is found to provide improved beam shaping and a significant decrease in the antenna axial ratio. The antenna is ideally suited for two-way communications via satellite to vehicles, vessels or aircraft. The antenna is a compact, low profile radiator exhibiting circular polarisation, making it  
15 ideally suited for use where size and performance are paramount such as in marine, aeronautical and land transport services.

Fig. 3 shows a typical radiation pattern for the antenna of Fig. 1. which is seen to have high radiated power gain compared to other types of antenna of similar dimensions.

20 The antenna of Fig. 1 has a low profile and a compact structure, thereby making it an ideal radiator when used alone. It can also be used as a radiating element in an antenna array. A further advantage is that since the antenna provides higher individual antenna gains than, for example, patch antenna elements, the complex phasing networks that are required in order to drive multiple antenna elements in a phased array can be replaced with a simple low loss antenna switching network in order to select individual  
25 antenna elements according to the direction required.



Fig. 4A shows a partial switched-element arrangement 400. A general omnidirectional antenna arrangement uses a series of 6 to 8 switched elements comprising small antennas according to the arrangement of Fig. 1, each antenna having a peak gain of at least 8 dBi after switching network losses. The depiction in Fig. 4A is directed to a single 90° quadrant between dashed lines 404 and 422 for ease of description. Three antenna elements 406, 402 and 420 are disposed on an antenna housing 418. The antenna elements 406, 402 and 420 are arranged so that their beam angles point in respective directions depicted by the dashed arrows 404, 424 and 422. The antenna elements 406, 402 and 420 are connected by respective feed lines 410, 416 and 414 to a switch arrangement 408, and thence by means of a connection 412 to the communications apparatus. The apparatus can be a transmitter, a receiver, or a duplexer to which both are connected for simultaneous transmit/receive.

It will be apparent that the small antennas according to the arrangement of Fig. 1 can also be incorporated into a phased array by introducing a phased array feed network, instead of the switched feed network shown in Fig. 5A, to thereby form a phased array antenna.

Fig. 4B depicts antenna beams 426, 430 and 434 that are associated with the respective antenna elements 406, 402 and 420, the beams being orientated along directions depicted by dashed arrows 404', 424' and 422' which correspond to respective directions 404, 424 and 422 in Fig. 4A.

From an operational perspective the beam 426, for example, can be selected by switching the line 412 to the feed line 410 using the switching arrangement 408. Similarly, the beam 434 can be selected by switching the connection 412 to the feed line 414 using the switching arrangement 408, and so on.

Fig. 5 shows an elevation pattern for the antenna shown in Fig. 1. The peak antenna gain is in excess of 9 dB, with broad coverage over elevation angles from 20 to 70 degrees.

The coverage at the zenith may be improved, if required, by incorporating an extra antenna element pointing to the zenith. This element is connected to the switched array 400, for example, to provide coverage at the zenith.

A single helix with only approximate manual pointing of the antenna would also be attractive for non-mobile applications.

### **Industrial Applicability**

It is apparent from the above that the arrangements described are applicable to the mobile communication industry.

The foregoing describes only some embodiments of the present invention, and modifications and/or changes can be made thereto without departing from the scope and spirit of the invention, the embodiments being illustrative and not restrictive.

In the context of this specification, the word "comprising" means "including principally but not necessarily solely" or "having" or "including" and not "consisting only of". Variations of the word comprising, such as "comprise" and "comprises" have corresponding meanings.

**The claims defining the invention are as follows:**

1. An antenna comprising:  
a ground plane:  
5 a helix disposed above the ground plane, the helix being connectable to a communications apparatus at a helix end located near the ground plane; and  
a spiral substantially centred on the axis of the helix the spiral having an outer end thereof connected to the other helix end, said spiral thereby terminating the antenna.
- 10 2. An antenna according to claim 1, wherein the axis of the helix is substantially perpendicular to the ground plane.
3. An antenna according to claim 2, wherein the spiral lies in a flat plane that is substantially perpendicular to the axis of the helix.
- 15 4. An antenna according to claim 3, further comprising a tapered transmission line connected between the communications apparatus and the end of the helix located near the ground plane.
- 20 5. An antenna according to claim 3, wherein:  
the helix has (a) between 1.5 and 3.5 turns, (b) a pitch angle of between 3 and 7 degrees, and (c) a circumference of between 0.9 and 1.15 wavelengths; and  
the spiral has between 2 and 4 turns.
- 25 6. An antenna comprising:  
a ground plane:

a plurality of helix elements disposed above the ground plane, each said helix being connectable, via a respective feed line of an associated phased array feed network to a communications apparatus, at a helix end located near the ground plane; and

5 a like plurality of spirals, each substantially centred on the axis of the corresponding one of the plurality of helix elements, said each spiral having an outer end thereof connected to the other helix end of the corresponding one of the plurality of helix elements, said spiral thereby terminating the corresponding helix element.

7. An antenna comprising:

10 a ground plane:

a plurality of helix elements disposed above the ground plane, each said helix being connectable, via a respective feed line of an associated switched element feed network to a communications apparatus, at a helix end located near the ground plane; and

15 a like plurality of spirals, each substantially centred on the axis of the corresponding one of the plurality of helix elements, said each spiral having an outer end thereof connected to the other helix end of the corresponding one of the plurality of helix elements, said spiral thereby terminating the corresponding helix element.

8. A method of impedance matching an antenna wherein the antenna comprises a  
20 ground plane, a helix disposed above the ground plane, the helix being connectable to a communications apparatus at a helix end located near the ground plane, and a spiral substantially centred on the axis of the helix the spiral having an outer end thereof connected to the other helix end, said spiral thereby terminating the antenna, said method comprising the steps of:

adjusting a distance, from the ground plane, of the helix end located near the ground plane to thereby adjust the impedance of a tapered transmission line formed between the ground plane and a first quarter turn of the helix.

5     9.       An antenna substantially as described herein with reference to the accompanying drawings.

10.       A method of impedance matching an antenna substantially as described herein with reference to the accompanying drawings.

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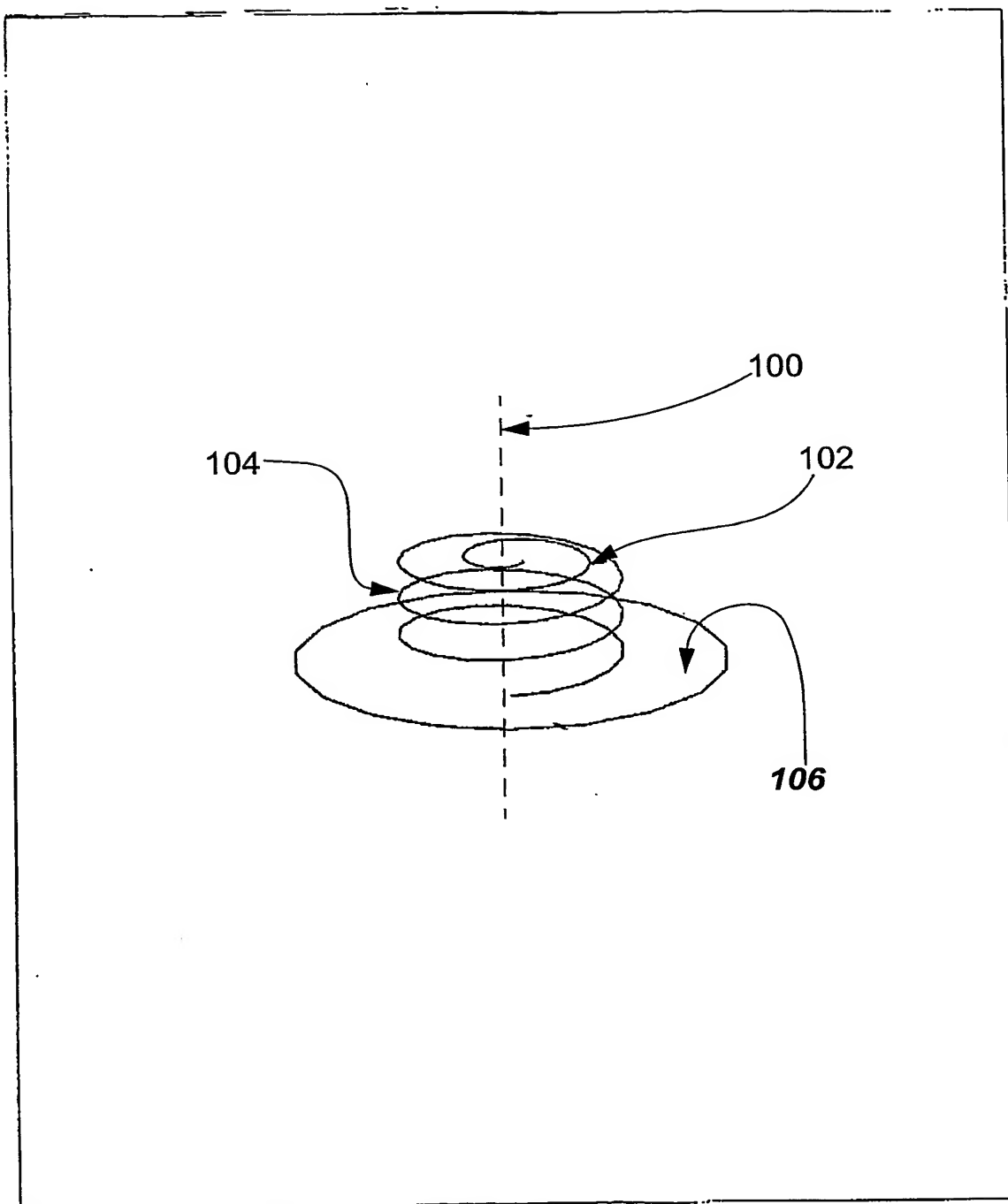
DATED this 11<sup>th</sup> Day of June 2002

**MARINE-WATCH LTD**

Patent Attorneys for the Applicant

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**SPRUSON&FERGUSON**



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**Fig. 1**

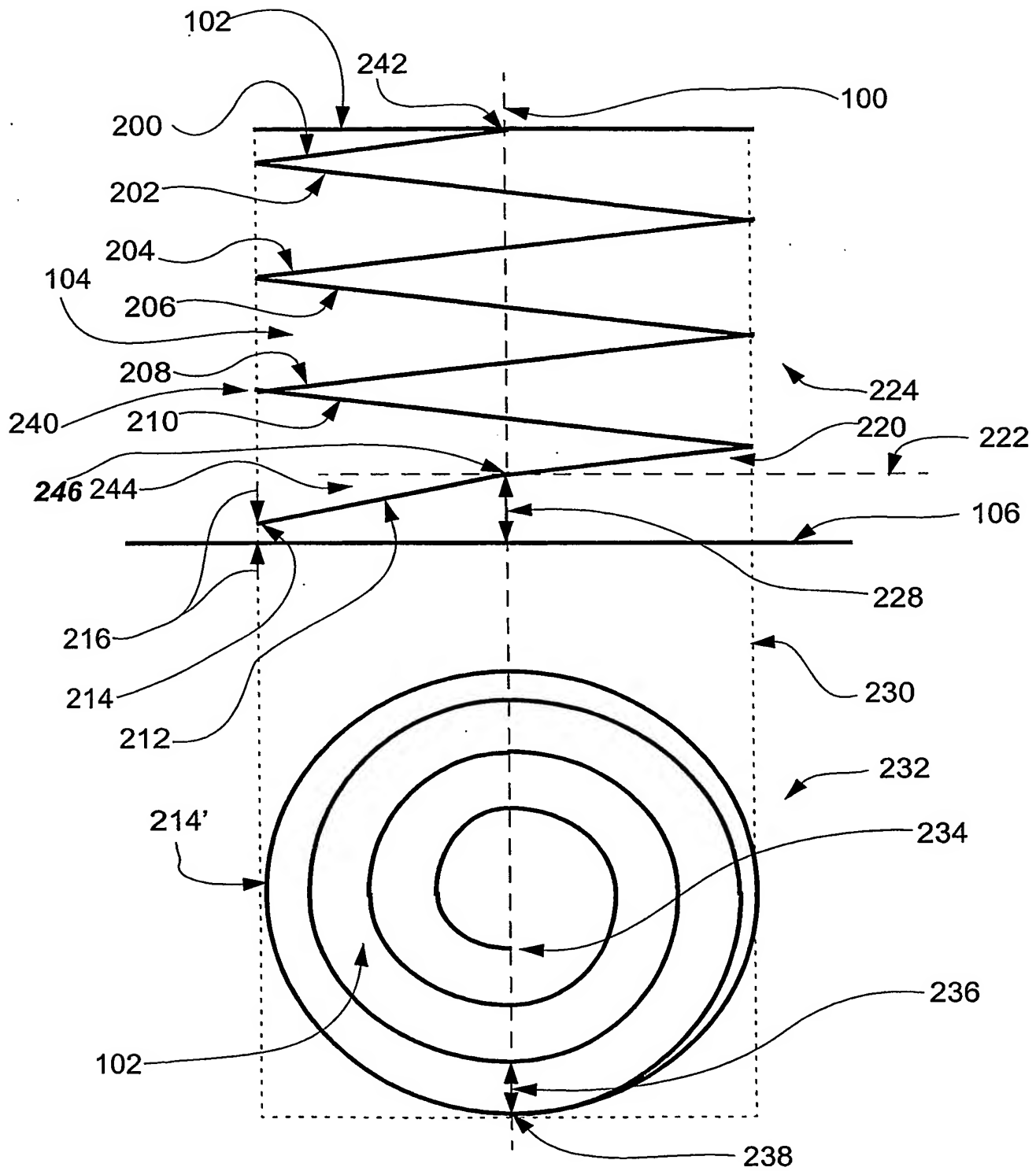


Fig. 2

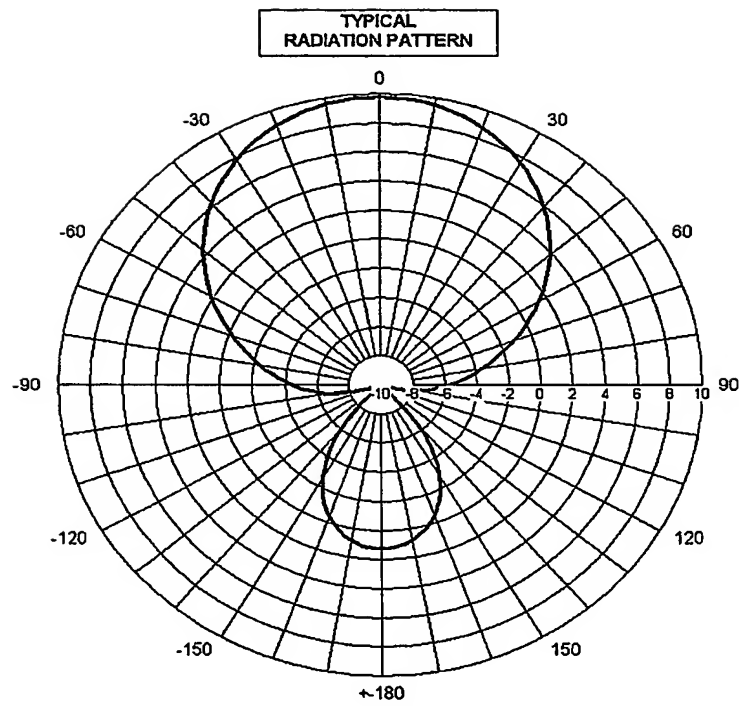
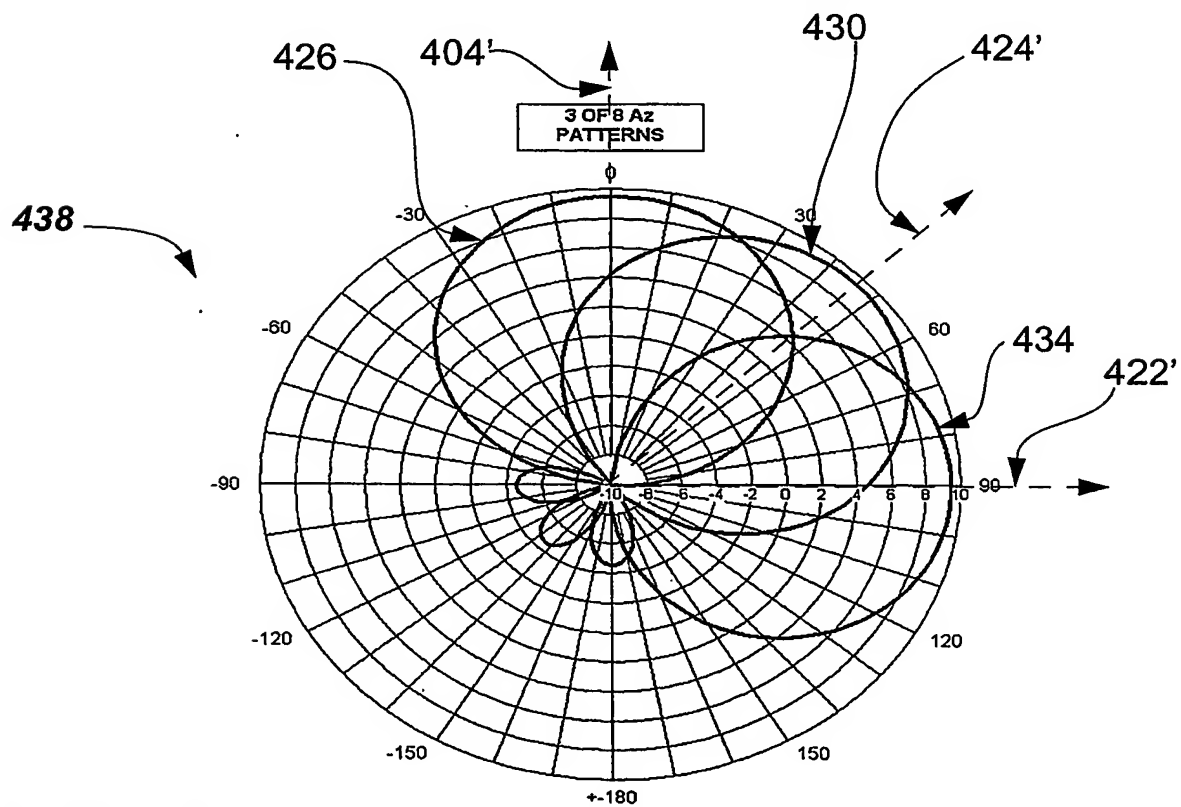
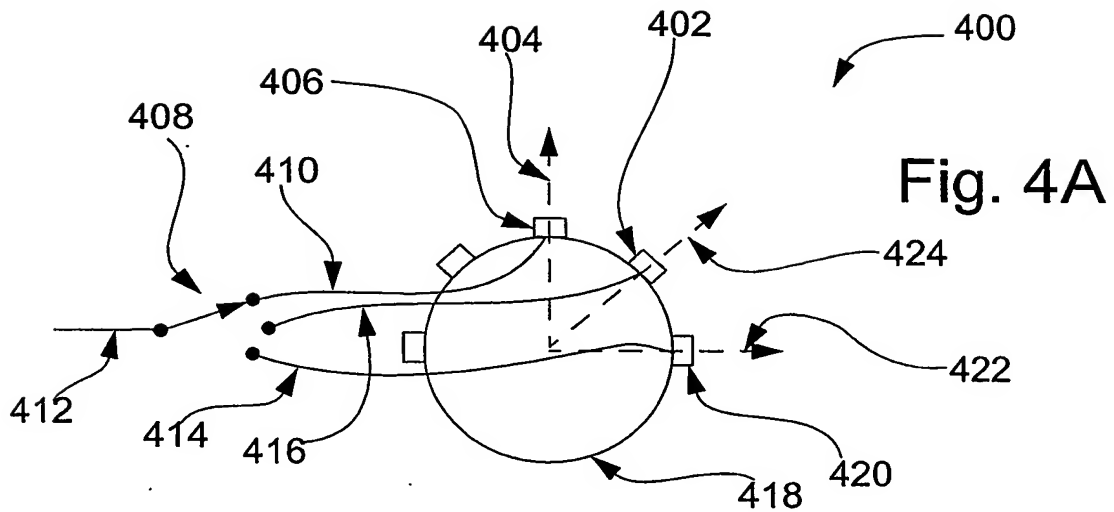


Fig. 3





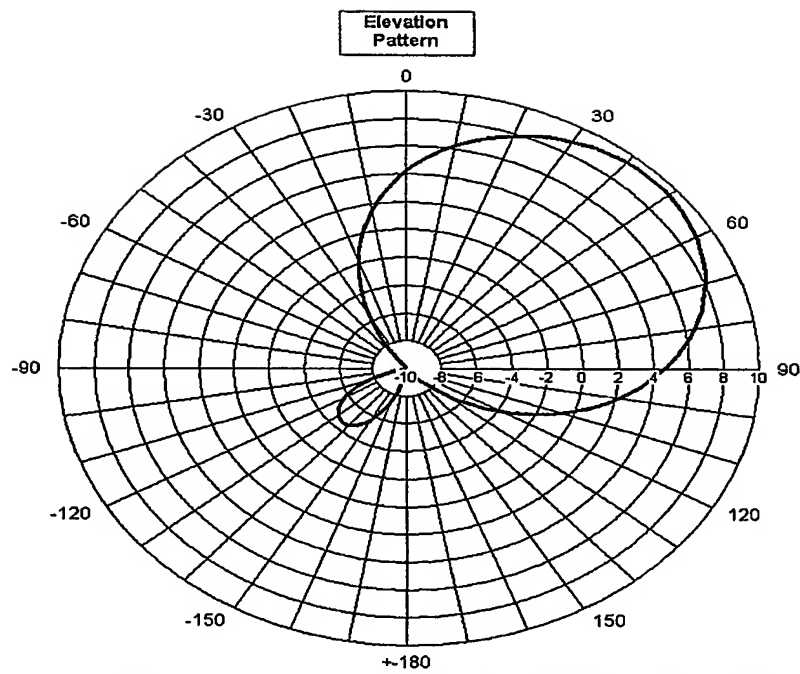


Fig. 5